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PAPER

IN

MECHANICKS.

MECHANICKS.

IN the year 1769, a Bounty of fifty Guineas was voted to Mr. Weſtgarth, for his invention of an Hydraulic Machine, which was then ſtrongly recommended by Mr. Smeaton, as will be ſeen by his letter, dated April 29 in that year.

Although, from that time, a Model has remained in the Society's Repoſitory, no account of the Machine has hitherto been publiſhed, by which the ſeveral contrivances can be clearly underſtood, but Mr. Smeaton having obliged the Society with a full deſcription, and correct drawings of all the parts, the whole is now ſubmitted to publick inſpection, as likely to prove of very conſiderable advantage in many ſituations, particularly among the Mines in various counties in theſe Kingdoms.

The Society, fully ſenſible of the Merits of Mr. Smeaton's account, voted him their thanks, and a Silver Medal, for the particular care he had taken in the deſcription of Mr. Weſtgarth's Machine, and for the attention he has ſhewn to the views of the Society in this inſtance.

The Repreſentation of JOHN SMEATON, *Engineer, concerning the HYDRAULIC ENGINE, invented by* Mr. WILLIAM WESTGARTH, *of* Colecleugh, *in the County of* Northumberland, *for raiſing Water by Water.*

MR. SMEATON, begs leave to advertiſe his friends and acquaintance, as well as all thoſe who are deſirous of promoting the ſucceſs of good mechanical inventions, that they will find the Engine, the Model of which will be exhibited by Mr. Weſtgarth, to be highly worthy of their attention and regard; being in his opinion, one of the greateſt ſtrokes of art in the Hydraulic way, that has appeared ſince the invention of the Fire Engine.. This Machine is founded on one of the moſt ſimple principles of ſtatics, viz. that of an heavier column of Water, preſſing up, or raiſing a lighter; an idea, which though proportinably obvious, as it is ſimple, and therefore far from new, having been adopted by ſeveral eminent Mechanicks; yet it has been reſerved to Mr. Weſtgarth, to form the proper expedients, and obviate thoſe difficulties, which attended the practical execution of machines intended to work on this principle; and which contrivances are (as to my knowledge) not only new and peculiar to Mr. Weſtgarth, but which alone have contributed to its ſucceſs: and therefore, though the whole compoſition dependant thereon, is highly deſerving a patent, or excluſive privilege, yet Mr. Weſtgarth, chuſing rather to exhibit and communicate his invention to the publick, ſeems, for that very reaſon, the more highly deſerving a reward from the patrons and encouragers of art; and the more worthy of proper notice, as he has not been haſty in communicating his invention until the value thereof has fully appeared, by a number of Engines built at large and applied to real uſe.

Independant of the various draughts, experiments, and eſſays on models, which, as I am informed, Mr. Weſtgarth, had in hand, for years, prior to his attempting a Machine in large; I had the pleaſure of ſeeing the firſt compleat Machine of this kind at work, for draining or unwatering a Lead Mine, belonging to Sir Walter Blackett, at Colecleugh, aforeſaid, in the ſummer of the year 1765; ſince which time, that Machine has been ſhewn to all thoſe who had the curioſity to ſee it. He has now erected four others in the different mines in that neighbourhood, one of which I have ſeen, and all attended with equal ſucceſs, as I have great reaſon to believe, not only from the nature of the conſtruction, but from the reports of thoſe for whom they have been erected. This machine is not only peculiarly adapted to the raiſing of Water by Water for draining of Mines, but the ſame principle can readily be extended to the raiſing of Water for ſupplying towns, gentlemen's houſes, &c. and univerſally for raiſing Water from any depth, wherever a fall of Water can be procured; and particularly in thoſe caſes where the fall is great; that is, where it exceeds thirty or forty feet, it will, in my opinion, not only exceed all other known Machines in effect, but in ſimplicity; and that whether the quantity of Water to be applied is great or ſmall. I therefore think this Machine is not only very curious in itſelf, but will be of great advantage to the publick.

J. SMEATON.

Auſthorpe,
April 29, 1769.

Deſcription of the Statical HYDRAULIC ENGINE, invented and made by the late Mr. WILLIAM WESTGARTH, *of* Colecleugh *in the County of* Northumberland, *by* J. SMEATON, F. R. S.

THE firſt of theſe Engines, was compleated by Mr. Weſtgarth, for the uſe of draining or unwatering a Lead Mine, at Colecleugh, belonging to the late Sir Walter Blackett, Bart. whoſe principal agent he was for that, and the reſt of his Mines in that neighbourhood. It was firſt ſet to work in the year 1765, and was at once attended with compleat ſucceſs; and I believe continues a working Engine at this day. In conſequence hereof, he was called upon by the Miners of the neighbouring Manor of Alſton-moor, belonging to Greenwich Hoſpital, to conſtruct Machines of the ſame kind, in ſuch ſituations as ſeemed elegible; and three or four more of the ſame ſort, were alſo made with ſucceſs in the courſe of three or four years, which induced Mr. Weſtgarth to think of applying for a patent for the excluſive privilege of uſing this invention; but previous thereto, he was pleaſed to adviſe with me concerning it, being at that time frequently in thoſe parts of the country, as an agent of Greenwich Hoſpital.

Much as I admired the ingenuity of Mr. Weſtgarth's invention, I diſſuaded him from the thoughts of a Patent; as it would take a length of time to be ſufficiently known, and the number of caſes in which it could be properly applied, were not ſufficient to be likely to afford ſuch a number of premiums, as might defray the expence of a Patent, with a proſpect of advantage to himſelf and family.

mily. I therefore recommended it to him, as the Society for the Encouragement of Arts, Manufactures, and Commerce, were, by handſome premiums and bounties, encouragers of all uſeful inventions and improvements, to communicate his invention to them, that it might be made publick; in confidence that he would obtain a bounty for the ſame, of ſuch value as to the Society ſhould ſeem meet: and in conſequence hereof, I gave him a repreſentation of the utility of his invention, with which, in the year 1769, he applied to the ſaid Society, and obtained a Bounty, upon condition he delivered to the Society, a working model, and a draught, ſhewing the conſtruction of the Engine; but as the death of Mr. Weſtgarth, which happened not long after, prevented the uſefulneſs of the Machine, from being ſo ſucceſsfully ſpread, as it otherwiſe doubtleſs would have been; and as ſome of the moſt eſſential parts of the Machine, cannot be ſeen in the model, without its being taken to pieces; and the drawing not being accompanied with any literal explanation, nor the detail of it ſufficiently made out. At the requeſt of the Society, I have now ſupplied thoſe defects, that it may be publiſhed in ſuch a manner, that the utility of it may be ſeen; and the means of making and applying it in a proper ſituation, explained.

The Hydraulic Engine, the moſt in uſe in the Mines, is vulgarly called the *Bob-gin*; and from the ſimplicity and eaſy application thereof to the ſituations and purpoſes of Mines, has been in uſe amongſt them, beyond the reach of any traces concerning its origin: It conſiſts of a Waterwheel, moſt commonly overſhot; a ſingle Crank or Winch, at one or at both ends of the Axis as occaſion may require, for the application of one or two balances, for the working of one or two pumps. Nothing can be more commodious in mountainous countries, when there is often great plenty of fall, and not an abundance of water.

There is however a limitation to the extent of the uſe of this Machine: for, when for the ſake of making the beſt uſe of a ſmall quantity of water, it would require the Water-wheels to exceed forty feet in diameter, or height, then they become ſo heavy, unweildy, and expenſive, as on thoſe accounts to be inelligible; and they rarely exceed fifty feet *. Where therefore a rich Mine, a neceſſity of power, and a ſcarcity

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* The largeſt I ever ſaw, was in Cornwall, and forty-eight feet diameter; the largeſt I ever conſtructed is forty-ſeven feet.

city of water concur; in former times, (before the uſe of fire engines) they frequently placed Water-wheels of a moderate ſize one above another; taking their water in ſucceſſion, and uniting their powers in one; but in this way, when more than two or three wheels are neceſſary, the Machine ſtill becomes unweildy and expenſive*. It was therefore a Deſideratum, by way of ſupplement to the water-wheel, to have a Machine on ſuch a conſtruction that would take in an unlimitted perpendicular fall, with any quantity of water however great or ſmall *: And efforts have not been wanting to produce a ſtatical Machine, whereby a heavier column of water might overcome and raiſe a lighter; but the means of conſtructing a Slide, Cock,

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* When I was firſt in Cornwall, in the year 1757, I was there told of a famous Engine, that had been worked in the memory of thoſe alive, but of which no traces were remaining; it was called the *Tower Engine*; and conſiſted, as well as I remember, of ten water-wheels, of twenty feet diameter, one above another, ſo that it required a building in the form of a tower to contain them. Every water-wheel, being furniſhed with its proper cranks, they were all united in their efforts by two ſpears common to all, which ultimately acted upon two pumps. I ſaw myſelf, on that journey, two water-wheels one under, and taking its water from the other, which (if I rightly remember) were forty-five feet diameter each; each working by a ſingle crank, a ſingle pump which lifted the water to each other. What an expence might here have been avoided, had they been acquainted

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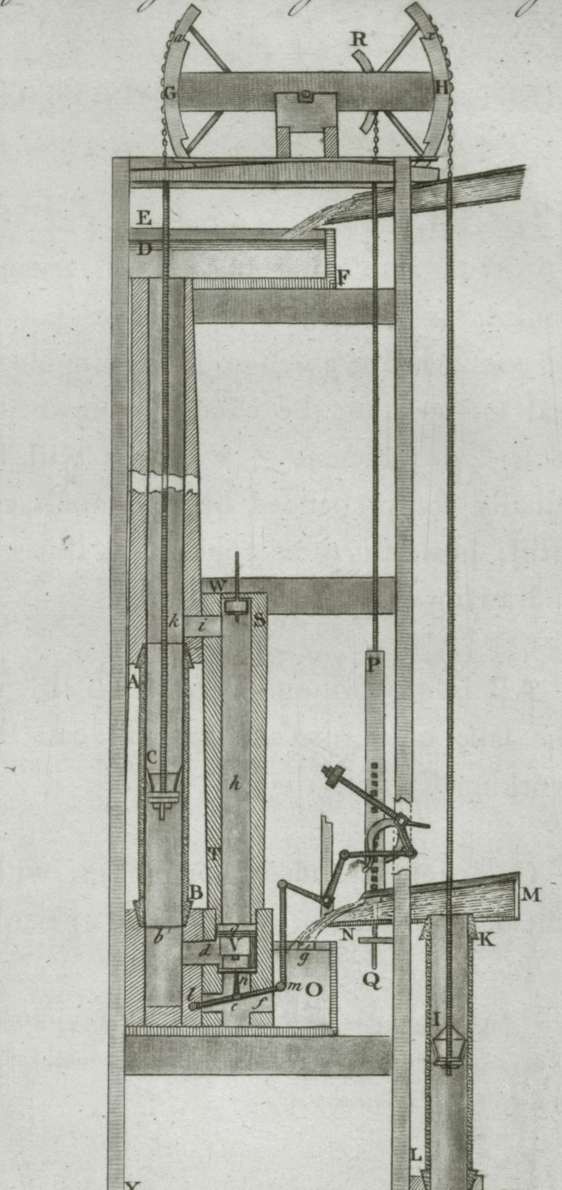
quainted with Mr. Weſtgarth's conſtruction; for beſides the expenſe of machinery, that of cutting out, and ſupporting the ground for the caſe, or cavity, wherein theſe wheels worked, being both under ground, will be ſeen by the experienced Miner, to have been no ſmall matter.

* About ſeventeen years ago, I erected an Engine upon Mr. Weſtgarth's principle, at Templenewſam, the ſeat of the Right Honourable Lord Viſcount Irwin, in Yorkſhire, for ſerving the houſe with Water, from an eligible ſpring. The perpendicular deſcent of the Water made uſe of as a power, was ſixty-ſeven feet; and the quantity expended at each ſtroke of the Engine, being only a ſingle Pint, ſhows how ſmall a quantity of water, may be uſefully em-

Cock, or Valve, whereby the preſſure of the acting column, might be alternately left at liberty to act, and its action ſuſpended, ſo as to do its buſineſs without too much friction, or wear in conſequence of it, was left to the invention of Mr. William Weſtgarth, who happily conceiving the idea of conſtructing a ſliding Valve in the form of a Cylinder, the action of a column of water upon its external ſurface, being equal all round, would have no tendency to drive it towards this ſide or that: And in this particular, the peculiar merit of his invention conſiſts.

employed in this mode of conſtruction.—This Engine delivers alſo a pint of water at each ſtroke into the reſervoir at the houſe; which is elevated above the ſpring, nearly half the perpendicular that the acting water deſcends; the diſtance being about two hundred and fifty yards: and as it will go ſixteen ſtrokes *per* minute, the water delivered amounts to eight barrels, beer meaſure; or fifty-five hogſheads *per* twenty four hours.

General Design of Mr. Westgarth's Statical Engine.



Contracted from Mr. Westgarth's Original Design by J. Smeaton 1787.

MECHANICAL DESCRIPTION OF THE ENGINE.

PLATE. No. 1. is a reduction of Mr. Weſtgarth's drawing, which accompanied his Model; it is therefore not to be conſidered as a deſign for an Engine in real ſervice; but the Model being made to a ſize ſufficient to work, it will be equally comprehended by the intelligent artiſt, how it is to be applied, as if it was a drawing of an Engine at large.

AB is a working Barrel, which, for the ſake of diſtinction we will call the working Cylinder.

C. denotes a Bucket or Piſton, without perforation*, being leathered upwards,

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* A ſmall hole through it, with a bit of leather upon it as a valve, was uſed by way of giving an occaſional paſſage to the air from below upward.

ſo as to prevent the water of a column reſting upon it, from deſcending, without the deſcent of the Piſton itſelf.

CD repreſents a column of water reſting upon the Piſton, of any perpendicular height, that is required, or that the ſituation admits of; being held in by the different lengths of pump-trees, that are placed above the working Cylinder; at the top of which is

EF a Ciſtern for receiving water from the ſupply or ſource.

Now ſuppoſe for a moment, that the working Cylinder was open at the bottom, that the Piſton ſupported by its rod or ſpear was ſuſpended by a proper chain upon the arch head G, of

GH the working beam, from whoſe end H by a ſimilar Chain, the ſpear HI deſcends down to I, which denotes the Bucket of an Engine-pump, with valves or falls, opening upward, as in common.

KL denotes the working Barrel of a common Engine-pump; which is placed within the preſſure of the atmoſphere, above the bottom of the mine or ſhaft, with as many lengths of pump-trees upon it, as will bring it up to the level of the drain, or ſough, by which the water of the Mine is to be diſcharged. The Trough MN is ſuppoſed to diſcharge the water from the Pump, into the Ciſtern O, placed at that level. Now it is evident by the conſtruction, that if the column of water CD is of a greater hydroſtatical weight, than that in the column of the Pump, the heavier column will overcome the lighter; and the column CD by deſcending, will raiſe the column of water in the Pump, and diſcharge it into the Ciſtern O: and the

Piſton C will continue deſcending, until, to prevent its getting below the working Cylinder, the arch head G is ſtopped by its pin at a; and in this poſition the Machine muſt ever remain; without the intervention of art.

If inſtead of the working Cylinder being open, as firſt ſuppoſed, it is connected with the pipes, b, d, e, f, which for the preſent moment may be ſuppoſed all open; then, if the ſeveral cavities under the Piſton, be ſuppoſed filled with water; this water, having free paſſage out at f, will not impede the deſcent of the Piſton, but diſcharging itſelf at f, riſe up at the Ciſtern O, until it runs over at the diſcharging place g, and there runs off into the ſough, along with the water diſcharged from the Pump. The Piſton will nevertheleſs remain in the ſame poſition wherein we before left it.

Suppoſe V to be a cylindrical valve, made to ſlide up and down upon the outſide of another hollow Cylinder; and that by means of ſquare holes through the ſame as repreſented under the valve V, the water communicates freely from the pipe d, to the pipe e, then there will be nothing to hinder the effect I have juſt decribed. But if we ſuppoſe that the valve V, is ſlided down, ſo as to cover thoſe holes, and at the ſame time, another ſet are opened above the ſliding valve, perfectly ſimilar to the former; but that there is a diaphragma, or ſtop in the bore of the inner Cylinder, betwixt thoſe two ſets of holes; ſo that there is no communication for the water, from the upper to the lower part of that Cylinder; then if there is by this means a communication opened between the pipe d, and the pipe h, through the upper ſet of holes; and alſo an open communication from the pipe h, through the pipe i, to the pump-tree at k; if the weight of the ſpear HI is heavier than that of G, C. and ſufficiently ſo to overcome the friction of the Piſton, Bucket, &c. there will then be nothing to hinder the Bucket from aſcending, becauſe the weight of the whole column DCb is ſupported and ſtopped from flowing out through the lower ſet of holes by the valve V, which now covers them: and there being nothing therefore to hinder the water diſplaced by the aſcent of the Piſton, from making its way progreſſively from the pump-trees at k, through i, h, d, and b, and ſo filling up the ſpace left by the Piſton; it will continue riſing, until, to prevent the Piſton's getting out at the top of the working Cylinder, the Arch Head H, is ſtopped upon the ſpring frame by its pin at x; and here again it muſt remain, until a new modification of the parts takes place. It is obvious, that if the valve V, is ſlid up again into the ſituation the figure repreſents it, that the column DCb again preponderating, will make a freſh ſtroke, and ſo *toties quoties*.

It is now proper to enter into a more particular explanation of the cylindrical Valve; and as Mr. Weſtgarth has given no enlarged drawing thereof, I have endeavoured to ſupply this, by what is contained in Plate No. 2. wherein Fig 1, repreſents the ſection, and Fig 2, the plan thereof, the letters refering to the ſame things in both.

AB, BA, repreſents the ſection of the ſliding valve marked V, in the Plate No. 1. being an hollow Cylinder, truly bored in the inſide; and open at both ends.

CD, EF is alſo an hollow Cylinder whoſe external ſurface is truly turned and wrought; ſo that the Valve may juſt ſlide eaſily upon it, without ſticking in any part.

CG, DG and EG, FG ſhew two flanches caſt in the ſolid upon each end of the internal Cylinder; which is in reality made of two pieces, for the ſake of getting the external Cylinder upon it; each piece having its own bottom: theſe are joined together by ſcrews, with a piece of thin leather, or oiled parchment between them.

HI is the bottom of the part of the Cylinder FHIE; and KLMN, is the bottom of the part of the Cylinder, CKLMND, leaving a groove round the Cylinder, whoſe ſection is O P: and thoſe bottoms form the ſolid diaphragma, or ſtop, by which all communication of water between the upper cavity of the Cylinder and the lower, is cut off from the lower.

QQQ, ſhew the places of three of the four ſquare openings, that are pierced through the ſides of the upper cavity of the internal Cylinder, and which, in this poſition of the cylindrical valve are covered thereby.

RRR, ſhew the places of three of the four ſquare openings, pierced through the ſide of the lower cavity; and in this poſition of the valve, are ſhewn as open.

ST, ſhews an iron bar affixed to the valve, and working through two ſlits cut through the under part of the interior cylinder, as VW, VW; this bar being laid hold of at the hole X, by an upright bar connected therewith, and its lower end with the lever, marked l m, in Plate No. 2. it is manifeſt how the motion of the valve V is managed by the rod attached to the lever l m, whoſe end m, coming out into the water of the open ciſtern, and being there laid hold of by the upright rod, the motion of the valve up and down, can be communicated from the common Tumbling Geer, as uſed in the Fire Engine; and the valve is made to open one ſet of holes, and ſhut the other alternately, at the end of each ſtroke of the Engine, by means of the plug frame P Q dependant from the little arch R, upon the working beam, in the ſame way as in the Fire Engine, which is diſtinctly ſhewn by the figure itſelf.

In conſidering the particular conſtruction of the valve Plate, No. 2. it is taken for granted, that the joint between the cylindrical valve, and the inſide cylinder upon which it ſlides, is perfectly water tight, notwithſtanding its ſliding motion; for if we ſuppoſe it not perfectly ſo, then the water acting through the holes Q Q Q and percolating through the crevice between the cylinders, will in effect open a partial communication between the upper cavity and the lower; and conſequently whatever this quantity is, will be a conſtant waſte of water, from the ſource to the ciſtern O, without doing any work: and though ſuperior artiſts might poſſibly effect ſuch a movement, yet it is not to be expected from the ſort of workmen uſually employed about hydraulic Engines in mines; and even if effected, as the continual wear of the parts would render the cavity of the valve larger, and the internal cylinder leſs; without ſome principle of accommodation to the rigidity of the materials, if delivered water tight out of the artificer's hands, they could not be expected long to remain ſo, after being in uſe. Such a principle of accommodation, Mr Weſtgarth's ingenuity and ſagacity provided, and introduced in the following manner.

The groove OP, is ſhewn to contain the ſection of a leathern ſtrap a b, ſuch leather as bridle-reins are made of, is fit for this purpoſe; a piece is cut, whoſe breadth is the ſame as the height of the groove, and whoſe length is about an inch, or rather better, longer than the circumference of the Cylinder. The two ends are to be thinned off in form of a wedge, but when brought together and overlapped, they will form nearly the ordinary thickneſs. A ſtrip of thin plate copper is alſo to be provided, whoſe breadth is ſuch as to go freely into the groove, and whoſe length is ſomewhat leſs than the circumference of the Cylinder; ſo that the leathern ſtrap being put into the cylindrical valve, and the ſtrip of copper (rendered circular) within it, the two ends of the copper are not to come quite in contract. The ſtrip of copper being ſuppoſed to have been rendered elaſtic by being well hammered, and ſet to a circle larger than that of the valve; when the ſtrap is confined within the ſliding valve, and the ſtrip of copper within the ſtrap, the conſtant endeavour of the copper-ſlip will be to enlarge the circumference of the ſtrap; and by cauſing it to ſtick cſoſe to the internal circumference of the valve, it will cloſe the joint between that and the external ſurface of the internal Cylinder; and effectually prevent the water getting down between the two Cylinders; and will enlarge itſelf in proportion to its own wear, and that of the bráſs work wherewith it is in contract.

Furthermore though all communication is by this means prevented from the upper immediately to the lower cavity; yet if the water acting through the holes QQQ, and through the crevice QE, QF, is not ſtopped by a water-tight joint between the upper end of the valve BB, and the flanch FG, EG, the water, making its way there into the general ſurrounding cavity, that contains the whole valve, will be at liberty to get through the lower holes RRR; and thence into the Ciſtern O; of the general deſign N°1. In like manner when the valve is down' if there is not a water-tight joint between the lower end of the valve AA, and its ſeat upon the lower flanch CG, DG, the water would eſcape from the ſurrounding cavity, through the crevice between the two Cylinders, and through the holes RRR, into the ſaid Ciſtern O. To prevent which, Mr. Weſtgarth, has introduced rings of flat leather upon both the flanches, to make good the ſeat of the valve, whether up or down; which rings of leather may be held down by braſs rings, whoſe ſections are repreſented at yy, zz, confined down by ſcrews: and theſe flat leathers ſerve a further purpoſe; for being made about half an inch larger than the circumference of the flanches, thoſe borders turned up, maintain a water-tight joint, between the valve and the general cavity in which it is lodged; marked in Plate No. 1. nq, and by unbolting and taking off the ſide pipe ST, the valve may be got at, taken out, and inſpected at pleaſure.

At W is repreſented a round block of wood, which by a ſcrew can be lowered at pleaſure; and as it is introduced in Mr. Weſtgarth's drawing, needs ſome explanation. I conceive it to be an expedient peculiar to the model (of which the drawing, as I have already hinted, is the deſign) to regulate the riſe of the piſton; which as it cannot riſe faſter, than the water can get round, from above to below it; by letting down this piece of wood, the paſſage i, can be ſo ſtraightened as to prevent the Piſton from riſing ſo ſuddenly as to diſorder the Working Geer. This in the work at large, is ſcarce neceſſary; becauſe this matter may be ſufficiently managed by the poize of the parts; whereas in the model, the friction bears ſo great a proportion to the whole power, that a ſmall difference of reſiſtance, will either make the Machine ſtick faſt, or allow it to go with too much rapidity; unleſs there is ſome curb upon it that will take place in proportion to its velocity.

To give the ingenious reader ſome idea of the real proportion of the parts, it may be proper to ſay, that in the Colecleugh Engine, according to the beſt of my memory, the working Cylinder was ten inches diameter, the deſcending Pumps were from twenty to thirty fathoms; and when the column of the Pump, was about half the hydroſtatical weight of the deſcending column, the Engine would go ten or twelve ſtrokes of ſeven feet each, per minute.

The working Beam was about twelve feet long.

The water ſhewn in the Ciſtern Y X Y, in the Model, is to repreſent the water generated in the mine; and from thence flowing to the Pump-foot at Z; to which is ſuppoſed to be annexed a proper length of ſuction pipe, according to circumſtances.*

O N.B.

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* On ſeeing this Engine in the Year 1765, Mr. S. ſuggeſted to Mr. W. that if this Engine, inſtead of the *Great Lever*

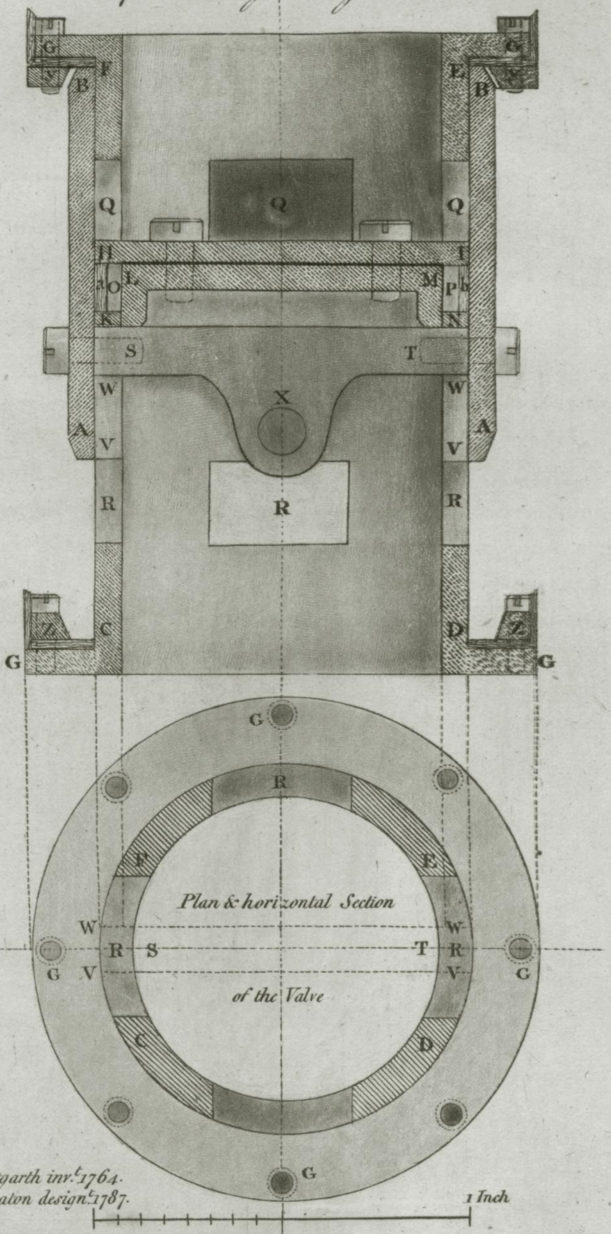
N. B. It may be proper to remark, that the ſcale of the valve, Plate No. 2. is ſixteen times larger than that of No. 1. and that a valve of four inches diameter is found ſufficiently large for a working barrel of eight inches.

Lever was made to work with a *Wheel*: and inſtead of the long Spear going down the deſcending Pump trees, the Piſton was made to communicate with the main chain through a collar of leathers, or *Stuffed Collar*, in the manner of (what is called) a *Jack-Head* Pump; that then the whole of the Machinery would ſtand together juſt above the *Level* or *Sough*, and there would take up leſs room, as the work might in general be comprehended within the limits of the *Shaft*, and the deſcending Pumps might alſo be of a leſſer bore, and be fixed in a corner of the Shaft, and therefore be upon the whole, much more convenient for under-ground works; and in this mode, the lateſt Engines of Mr. Weſtgarth, were actually conſtructed with ſucceſs.

PAPER

Plate 2

Section of Mr Westgarth's cylindrical Valve.



W. Westgarth inv.t 1764.
J. Smeaton design.t 1787.

ERRATA.

Page 11 line 1. for *next*, read *firſt*.
39. 6. for *if you Society will*, read *if your Society will*.
108. laſt line after *fair*, read *water*.
182. 2,3. for *proportinably*, read *proportionably*.
289. at the end, add 1789.
323. 16. for *horizonal*, read *horizontal*.
382. 10. before *Smith*, add *